THE WEATHER AND CIRCULATION OF DECEMBER 1951[1]

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The mean 700-mb. circulation in the Northern Hemisphere during the month of December 1951 (fig. 1) was characterized by the presence of three long (planetary) waves in the main band of westerlies at middle latitudes. The principal troughs composing this wave pattern were located in east-central North America, the western Pacific, and western Asia; while the ridges were found in the eastern Pacific, central Siberia, and western Europe. At higher latitudes abnormally deep Lows, near Baffin Island, east Greenland, and Spitzsbergen, dominated the circulation. The wave number was considerably greater at low latitudes, where six "High" cells and an equal number of troughs were present. The low-latitude trough in the eastern Pacific, off Lower California, extended northward to about 33° N. This latitude also marked the southern boundary of the trough located in eastern Canada at high latitudes and in the central United States at middle latitudes. As a result, a well-marked zone of confluence between warm southwesterly and cold northwesterly flow was centered in northeast Texas.

Further details of the Western Hemisphere circulation in December 1951 are revealed by the field of mean 700-mb. geostrophic wind speed shown in figure 2. The

[1] See Charts I–XV following p. 225 for analyzed climatological data for the month.

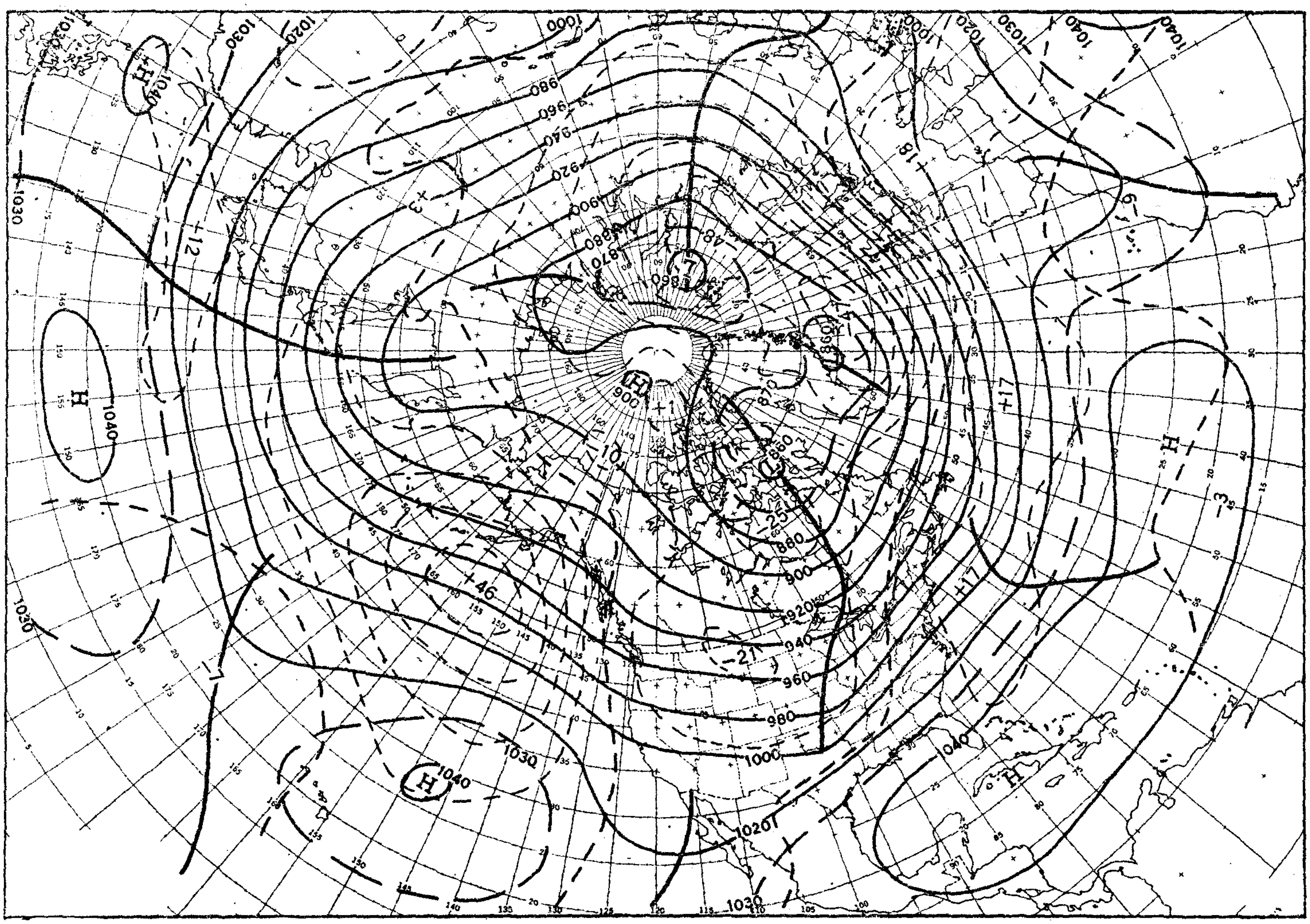


FIGURE 1.—Mean 700-mb. chart for the 30-day period December 1–30, 1951. Contours at 200-ft. intervals are shown by solid lines, intermediate contours by lines with long dashes, and 700-mb. height departures from normal at 100-ft. intervals by lines with short dashes with the zero isopleths heavier. Anomaly centers and contours are labeled in tens of feet. Minimum latitude trough locations are shown by heavy solid lines.

average wind in the United States attained its maximum speed (over 20 m. p. s. or 45 m. p. h.) in southwesterly flow just downstream from the confluence zone in Texas and just east of the trough in the Central Plains. This jet extended with virtually undiminished strength across the entire North Atlantic Ocean into southern Scandinavia. Its intensity was much greater than normal, as indicated by the fact that 700-mb. heights were above normal (fig. 1) over most of the southeastern United States, central Atlantic, and southern Europe, but well below normal over Canada, the northern Atlantic, and northern Europe. This jet stream was associated with severe storminess over the northern Atlantic during the last week of December, when three sizable ships sank off the coast of Europe and the freighter, *Flying Enterprise*, was abandoned by all but its gallant captain, Kurt Carlsen. In the eastern Pacific and western North America the jet stream was considerably weaker, with maximum wind speeds of only 14 m. p. s. (31 m. p. h.) in northwesterly flow off the coast of Oregon. The jet was slowest south of Kodiak as it traversed a mean ridge and strong positive 700-mb. height anomaly center (+460 feet located at 50° N., 155° W.). In fact, the westerlies were generally weaker than normal throughout the Pacific, as indicated by the presence of a broad belt of positive 700-mb. height anomalies at middle latitudes.

Figures 1 and 2 portray the mean state of the circulation in December. Additional information can be obtained by considering the day-to-day variability of the circulation during this month. The 24-hour or interdiurnal pressure changes at sea level were therefore averaged, without regard to sign, at standard 5° intersections of latitude and longitude and then plotted and analyzed, as illustrated in figure 3. The greatest amount of pressure variability, averaging more than 12-mb. per day, was observed in the northern Atlantic in a belt extending from Nova Scotia to Iceland. The location and orientation of this belt was similar to that normally found during winter [1], but the magnitude of this month's pressure changes was greater than normal, and the center of maximum change (15 mb.) was located just southeast of Newfoundland rather than northwest of the island as normally observed. Another center of maximum interdiurnal pressure change was located in the Central Great Plains of the United States, where the average change of over 10 mb. per day was more than twice its normal value. The zonal axis of maximum interdiurnal change in the north-central United States was generally south of its normal position along the Canadian border, so that daily pressure variability exceeded normal in most of the United States, except for the upper Lakes and Southeast. On the other hand, daily pressure variability was below normal in most of Greenland, eastern Canada, southern Alaska, and British Columbia. In all parts of the map south of 40° N. pressure variability generally decreased with latitude in the usual fashion, with average changes of less than 1 mb. per day observed at extremely low latitudes.

Comparison of figures 2 and 3 reveals some interesting parallels between the patterns of wind speed, derived from the monthly mean chart at 700 mb., and pressure variability, derived from 30 daily maps at sea level. In all sections the mean jet stream at 700 mb. generally meandered parallel to, but slightly south of, the primary axis of maximum interdiurnal pressure change. Values of both elements were generally high in middle latitudes but less in tropical and polar regions. A conspicuous exception, however, was found in northern Alaska and

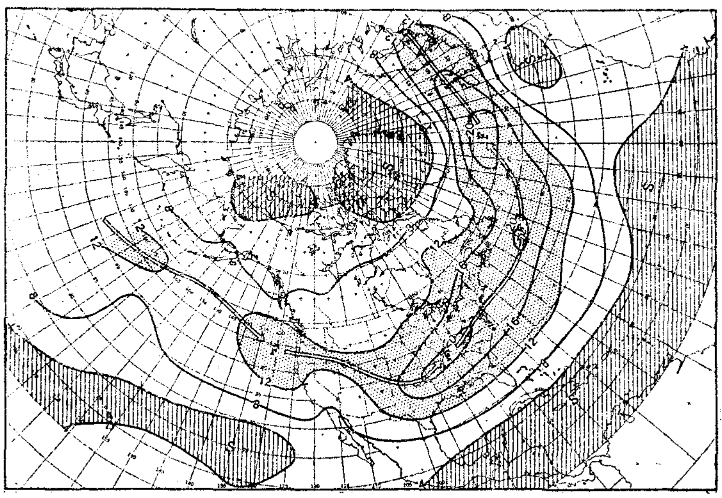


FIGURE 2.—Mean geostrophic (total horizontal) wind speed at 700 mb. for the 30-day period December 1-30, 1951. Solid lines are isotachs at intervals of 4 meters per second, while the double arrowed lines delineate the axes of maximum wind speed (jets). Areas with speeds in excess of 12 m/sec. are stippled while those with less than 4 m/sec. are hatched. Centers of maximum and minimum wind speed are labeled "F" and "S" respectively.

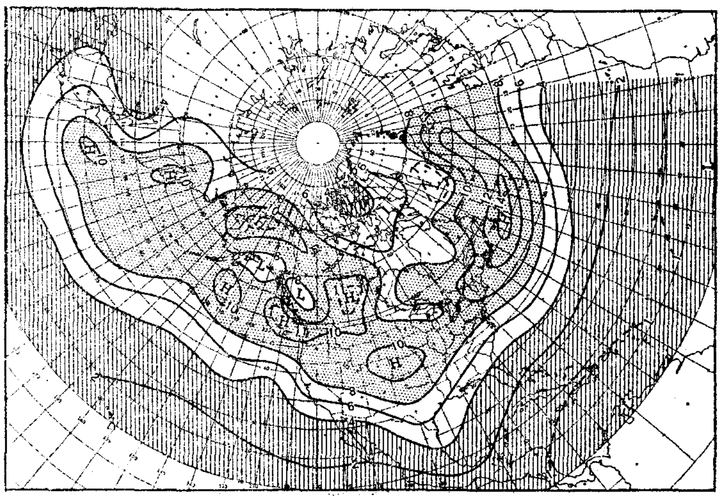


FIGURE 3.—Geographical distribution of absolute average interdiurnal pressure change at sea level for the period December 1-30, 1951. Isopleths at 2-millibar intervals are shown by solid lines with intermediate isopleths dashed. Areas with average pressure change less than 4 millibars are hatched, while those with more than 8 millibars are stippled. Centers of maximum and minimum pressure change are labeled "H" and "L" respectively.

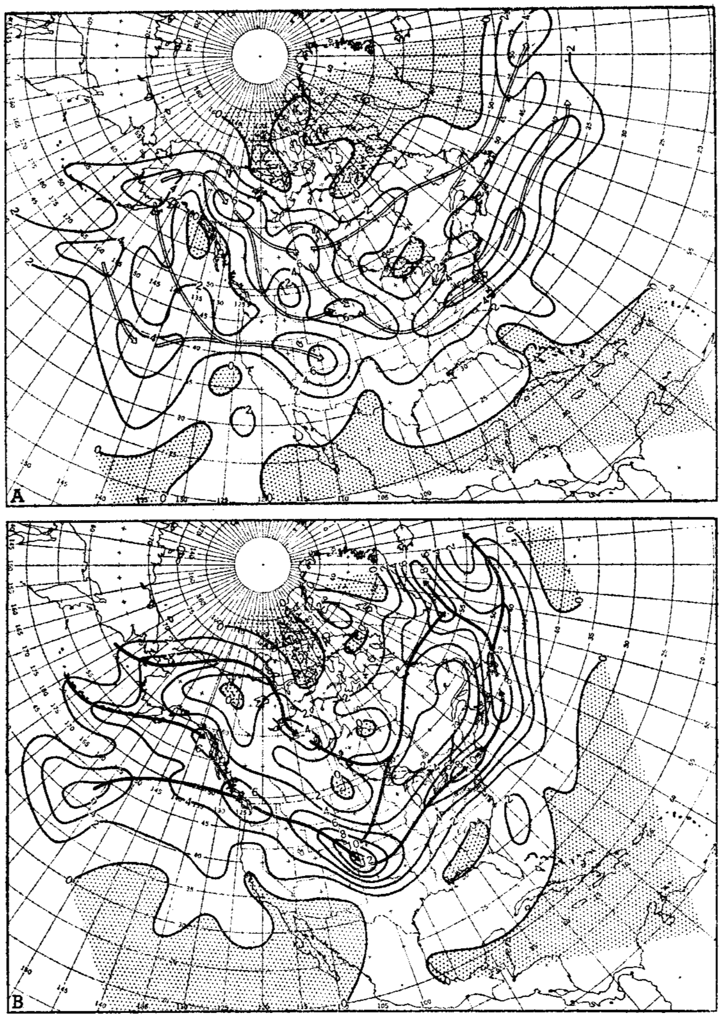


FIGURE 4.—Geographical frequency of tracks of anticyclones (A) and cyclones (B) observed during month of December 1951 within approximately equal-area boxes of size 5 midlatitude degrees of longitude by 5° of latitude. The isopleths are drawn at intervals of 2, and areas of zero frequency are stippled. The principal anticyclone and cyclone tracks are indicated by open and solid arrows, respectively, and are broken in areas of maximum frequency. All data obtained from Charts IX and X.

western Canada, where an axis of maximum pressure variability had no direct counterpart in the wind field. It is also noteworthy that in the northern Atlantic, central United States, and northern Alaska, pressures were more changeable than normal and, correspondingly, the westerlies at 700 mb. were stronger than normal. Although the isopleths in figure 3 are primarily zonal in orientation, regions in which pressure variability exceeded the latitudinal average were found chiefly in the western Atlantic, western Pacific, Great Plains of the United States, and western Canada. All these regions, except the last, were occupied by minimum-latitude troughs at either 700 mb. (fig. 1) or sea level (Chart XI). Conversely, in the mean ridges at sea level and aloft, in the eastern parts of the Atlantic, United States, and Pacific, interdiurnal pressure changes generally averaged less than the latitudinal mean. Thus the field of average daily pressure variability over most sections appears to be defined fairly well by the mean wind field and mean circulation pattern, despite the fact that variability cannot be determined from mean values.

Interpretation of the general circulation is facilitated further by reference to the tracks of anticyclones and cyclones, Charts IX and X. In order to delineate the principal tracks in a more objective manner, the number of tracks crossing squares of approximately 5° were counted, plotted, and analyzed, separately for anticyclones and cyclones. Idealized tracks were then drawn through the axes of maximum track frequency, as illustrated in figure 4. Since this figure takes no account of intensity of centers, it cannot be expected to correspond exactly to figures 2 and 3. Nevertheless, some striking similarities are apparent.

Throughout the Western Hemisphere the axis of the 700-mb. jet stream was in close proximity to a principal track of both anticyclones and cyclones. The former track was found in the region of anticyclonic shear just south of the jet, while the latter was located in cyclonic shear to the north. The cyclone track just north of the jet stream corresponded closely with the primary zonal axis of maximum interdiurnal pressure change at middle latitudes, although some anticyclones were also responsible for large pressure variability in this zone. The region of maximum pressure change in Alaska and northwest Canada, however, was traversed by slightly more anticyclones than cyclones. Migratory cyclones and anticyclones were infrequent in Greenland, eastern Canada, and the tropics, where pressure variability was small.

Of special significance was the unusual concentration of cyclone tracks in the United States. In both the Central Plains and the North Atlantic States there were more cyclone passages than in any other part of the Western Hemisphere. On the other hand, only a small number of storms were observed along the border between the United States and Canada, and along the St. Lawrence Valley, where cyclone frequency is normally large in winter [2]. In other words, "Colorado" Lows were abundant but "Alberta" Lows were scarce [3]. The principal cyclone track across the United States was therefore located south of its normal position, corresponding to southward displacements of the mean jet stream (fig. 2) and the zonal axis of maximum interdiurnal pressure variability (fig. 3). These conditions were reflected in the presence, over most of the United States, of cyclonic curvature at nearly all levels of the troposphere (Charts XII to XV), below-normal heights at 700 mb. (fig. 1), and lower-than-normal pressures at sea level (Chart XI inset).

Thus the weather during December 1951 was unusually stormy and changeable in most of the United States. State-wide precipitation averaged above normal in 40 of the 48 States in the country, and snowfall was very heavy in the West and in the North (Chart IV). In the Northeast, recurrent fast-moving storms coated the countryside with snow, sleet, or glaze, paralyzing transportation and disrupting communication in scores of large cities. A notable example was the storm of December 14, which caused the worst traffic jams in the histories of Washington, Baltimore, and Philadelphia, and was followed within a week by two similar storms. In Chicago, 33.4 inches of snow fell this month, a record for December and more than the normal amount for an entire winter. Snowfall was also unusually heavy in Watertown, N. Y., where 86 inches, the greatest amount since 1900, fell during November and December. In South Dakota, where Statewide precipitation averaged 259 percent of normal, skiplanes were used to provide emergency supplies to three towns isolated by snow drifts reported to be 15 feet high. Even California had its share of bad weather, as more than twice the normal amount of precipitation fell. On December 1, a 60 m. p. h. westerly gale in San Francisco was responsible for the temporary closing of the famous Golden Gate Bridge for the first time in its history. Strong winds also damaged power lines and citrus fruits in the San Fernando Valley. On the last 2 days of the month heavy snow produced avalanches and snowslides in the mountainous portions of the State.[2]

The moisture for this month's precipitation (Charts II and III) came from two primary sources, the Gulf of Mexico and the Pacific Ocean. Gulf moisture predominated from the Mississippi Valley to the Atlantic Coast, where southwesterly flow ahead of the trough was much stronger than normal at both 700 mb. (fig. 1) and sea level (Chart XI). Pacific moisture was responsible for most of the heavy precipitation observed from the Northern Plains and Rocky Mountain States westward to the Pacific Coast. By the time this Pacific air reached the eastern portion of the Plains most of its moisture had been precipitated west of the Continental Divide and its relative humidity had been lowered by foehn warming. At the same time this region was too far west to be affected by much Gulf moisture. As a result a narrow band of subnormal precipitation extended from southern Texas northeastward to Lake Superior. The deficiency of precipitation was particularly marked in central parts of Texas and Oklahoma, where less than 10 percent of normal amounts fell (Chart III–B) and dust storms occurred. This region was just south of the principal cyclone track (fig. 4B) and had much stronger than normal westerly winds (fig. 1), so that the "rain-shadow" effect in the lee of the Rockies was unusually pronounced.

The location of the principal cyclone track in the central United States was reflected in an intensified meridional gradient of surface temperature in most of the country (Chart I–A). This effect was superimposed upon the presence of stronger than normal southerly wind components at both sea level and aloft in the eastern half of the United States, while an excess of northerly flow generally prevailed in the western half of the Nation. As a result monthly mean temperatures were as much as 8° below normal in parts of the Northwest and Northern Plains, but not far from normal in the Southwest; while positive anomalies exceeded 5° in portions of the Southeast, but amounted to only a degree or two in the Northeast (Chart I–B). The weather was especially warm in the East during the first decade of the month. Baltimore, Md., had its warmest December week in history from the 4th to 11th, and daily high temperature records were broken in Washington, D. C. on the 7th (73° F.) and 9th and in Louisville, Ky. on the 6th. Another warm spell at the end of the month sent temperatures soaring to 90° in Fort Worth, Tex., on the 30th and 81° in Montgomery, Ala., on the 31st. On the other hand, record low temperatures were observed in Ely, Nev., on the 9th and Helena, Mont., on the 26th.

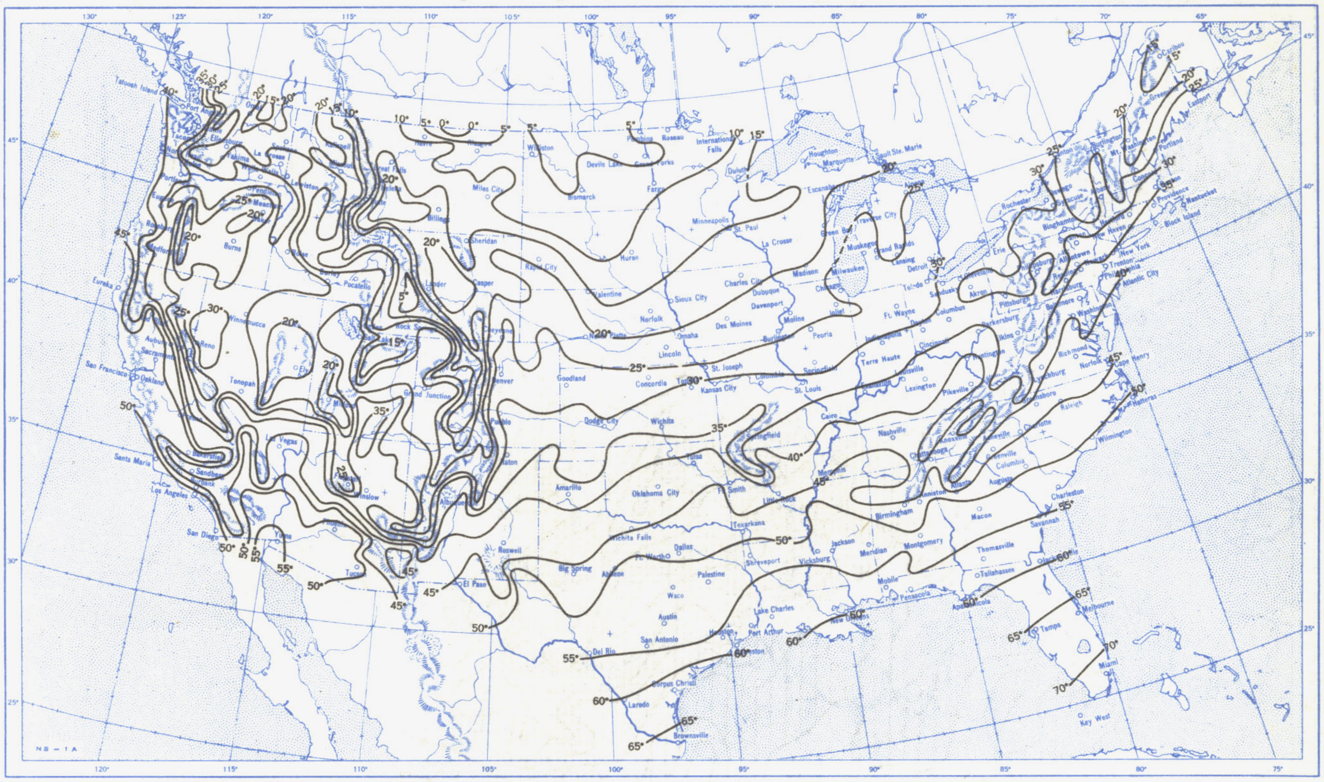
It is interesting to note that the line of zero monthly mean temperature anomaly (Chart I–B) practically coincided with the principal cyclone track (fig. 4B) in the region from Colorado to Lake Erie. This track may then be considered as a quasi-stationary frontal zone, separating cold continental polar and Arctic air masses to the north from warm maritime tropical and Pacific air to the south. This mean frontal zone was particularly well delineated in the Central Plains, where it separated temperature anomalies of as much as −4° in Kansas from anomalies of as much as +6° in Texas. This intensification of the normal temperature difference between Texas and Kansas has been a characteristic and enigmatic feature of almost every season during the past 2 years [4].

[2] A more detailed discussion of West Coast storminess during December is given in the following article by J. A. Carr. Other weather highlights during the month are discussed in the February 1952 issue of *Weatherwise*, pp. 18–20.

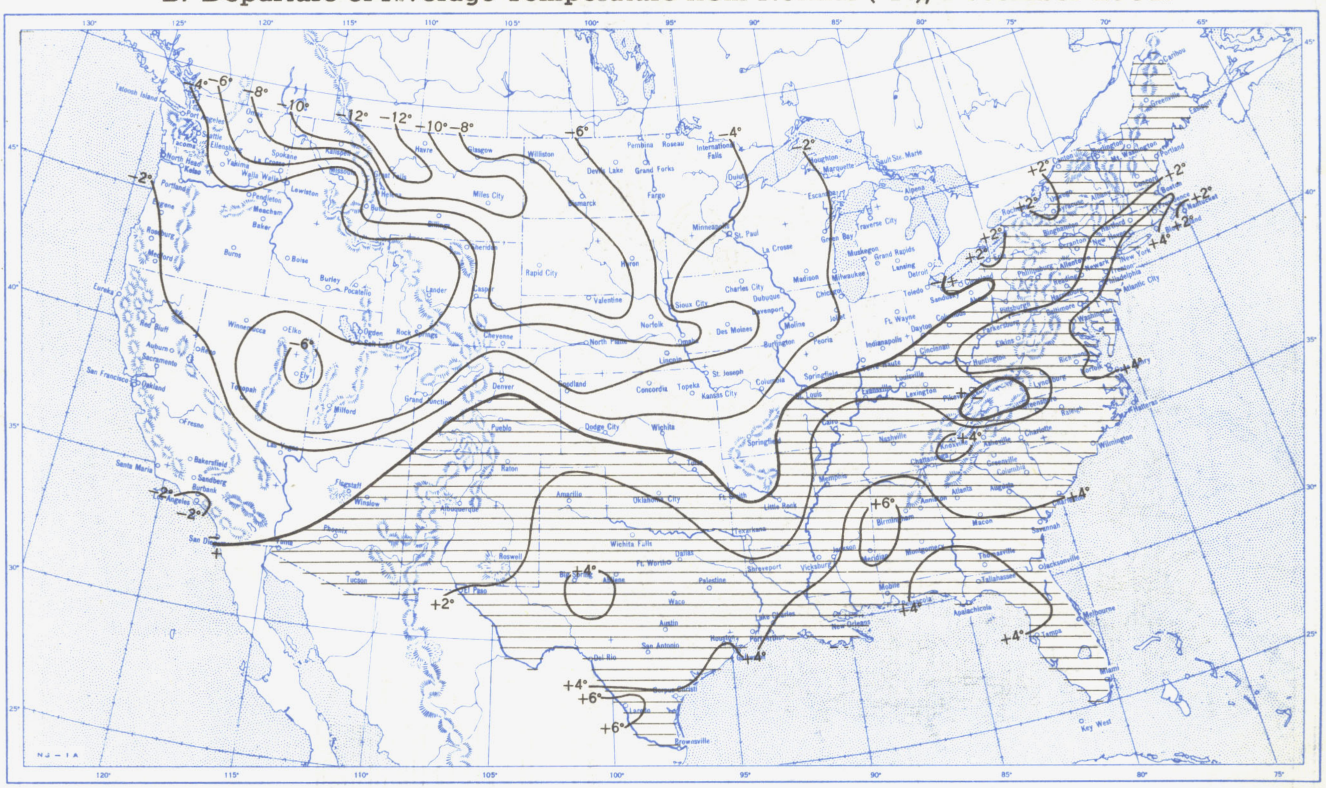
REFERENCES

1. W. H. Klein, "A Hemispheric Study of Daily Pressure Variability at Sea Level and Aloft," *Journal of Meteorology*, vol. 8, No. 5, October 1951, pp. 332–346.
2. S. Petterssen, "Some Aspects of the General Circulation of the Atmosphere," *Centenary Proceedings of the Royal Meteorological Society*, 1950, pp. 120–155.
3. E. H. Bowie and R. H. Weightman, "Types of Storms of the United States and Their Average Movements," *Monthly Weather Review, Supplement No. 1*, July 1914, 37 pp.
4. H. F. Hawkins, Jr., "The Weather and Circulation of September 1951," *Monthly Weather Review*, vol. 79, No. 9, September 1951, pp. 79–82.

Chart I. A. Average Temperature (°F.) at Surface, December 1951.



B. Departure of Average Temperature from Normal (°F.), December 1951.

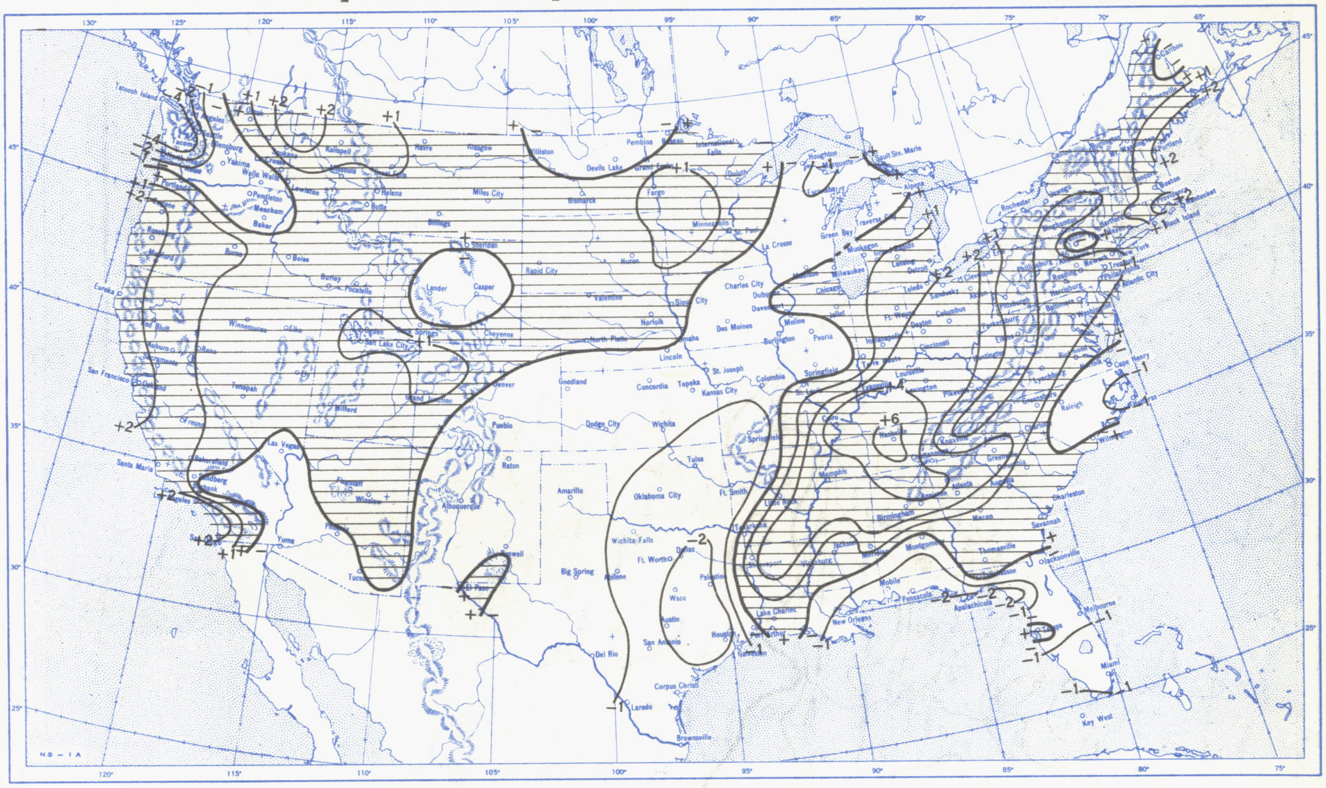


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

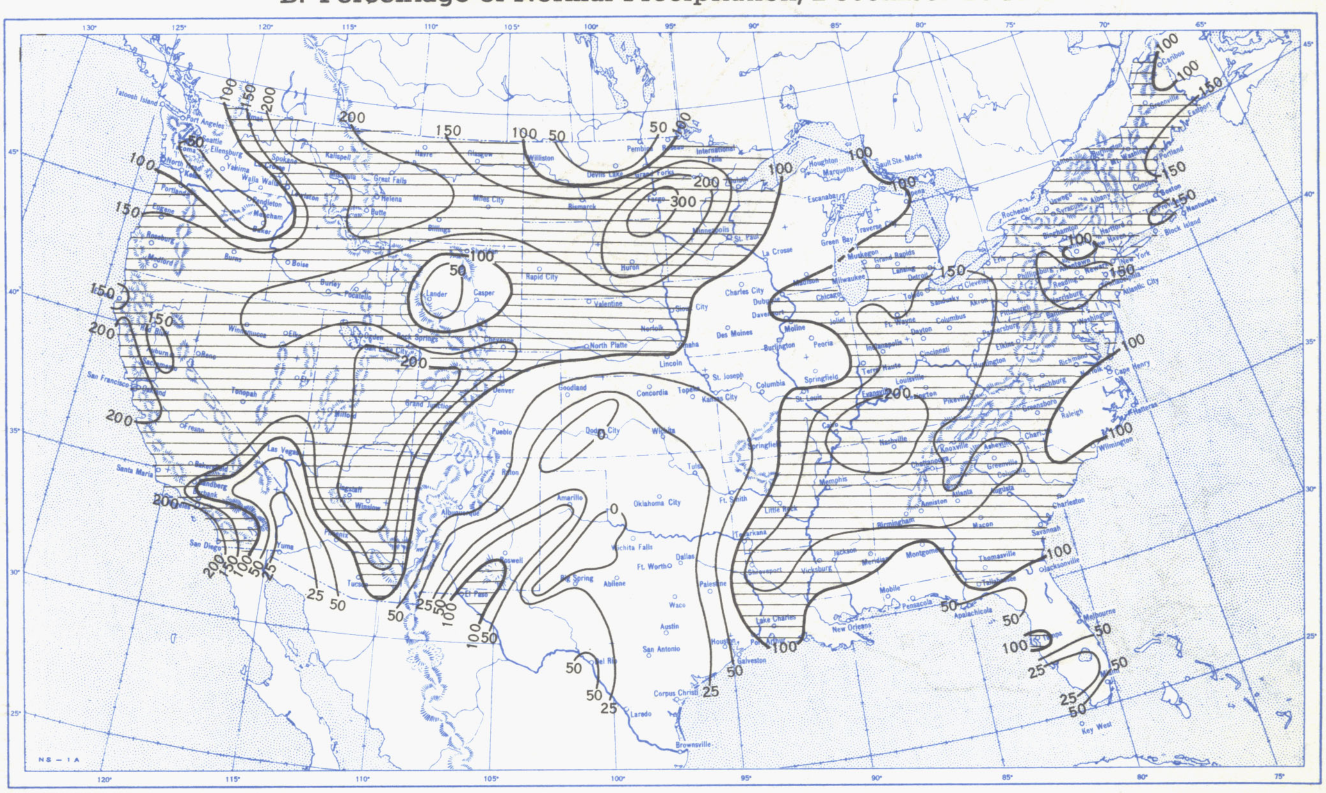
Chart II. Total Precipitation (Inches), December 1951.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), December 1951.

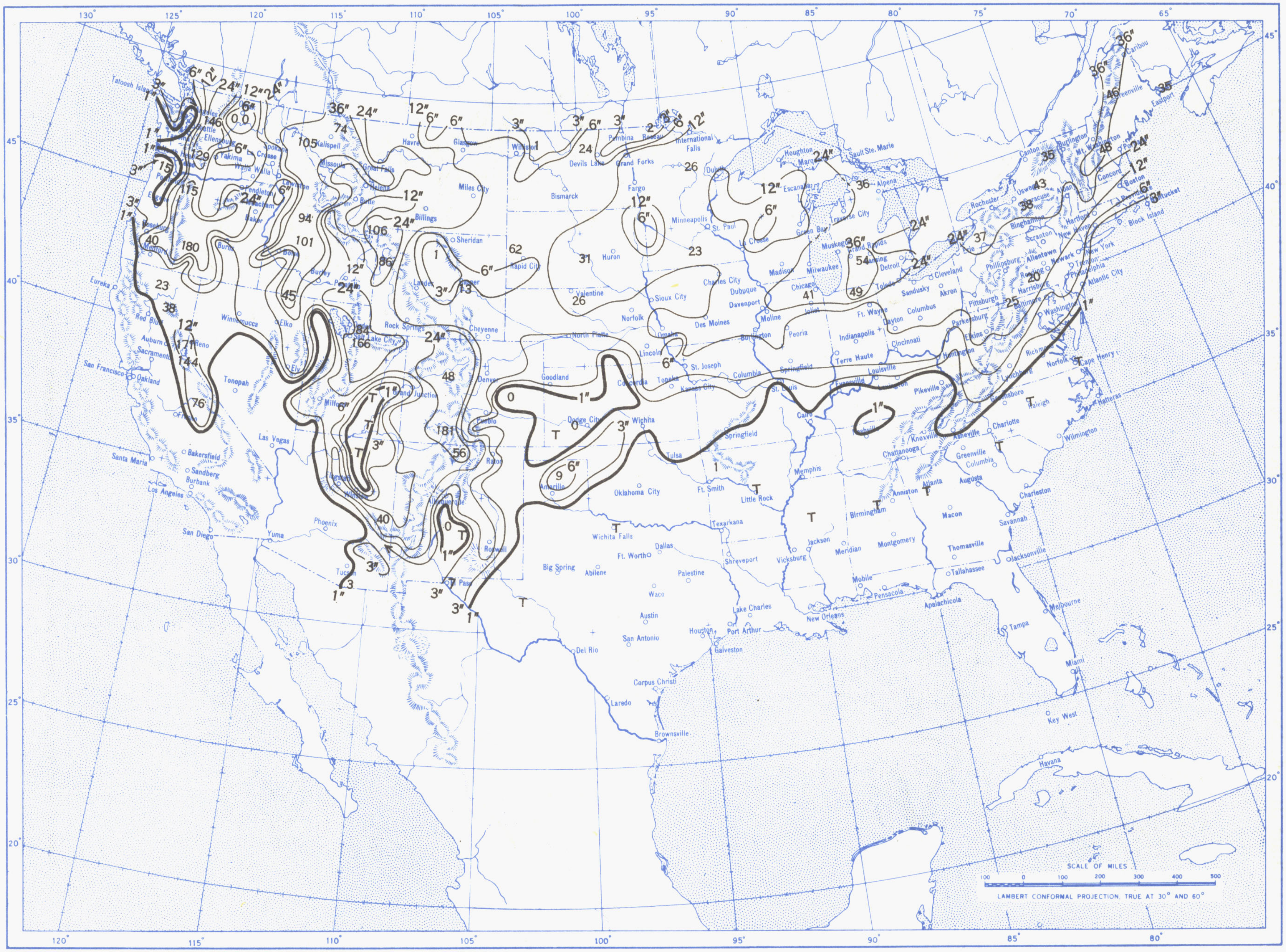


B. Percentage of Normal Precipitation, December 1951.



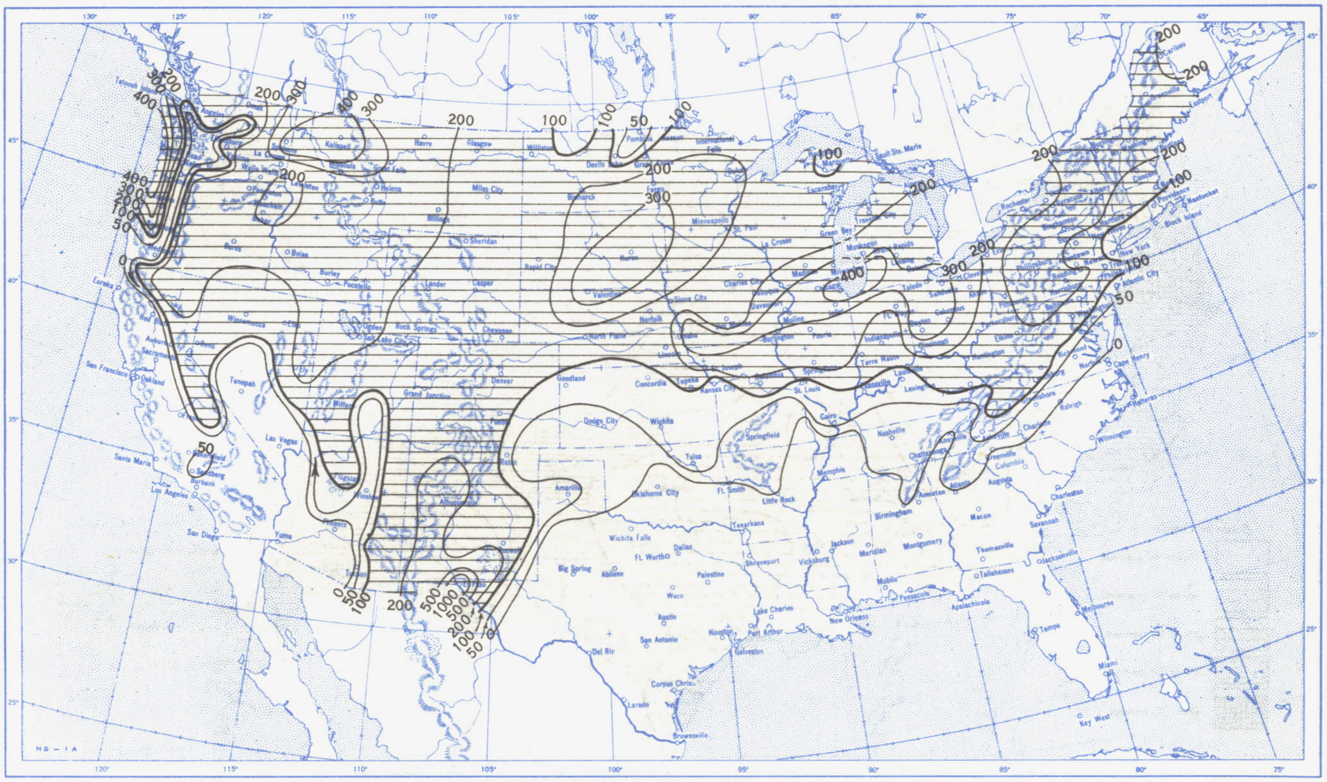
Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart IV. Total Snowfall (Inches), December 1951.

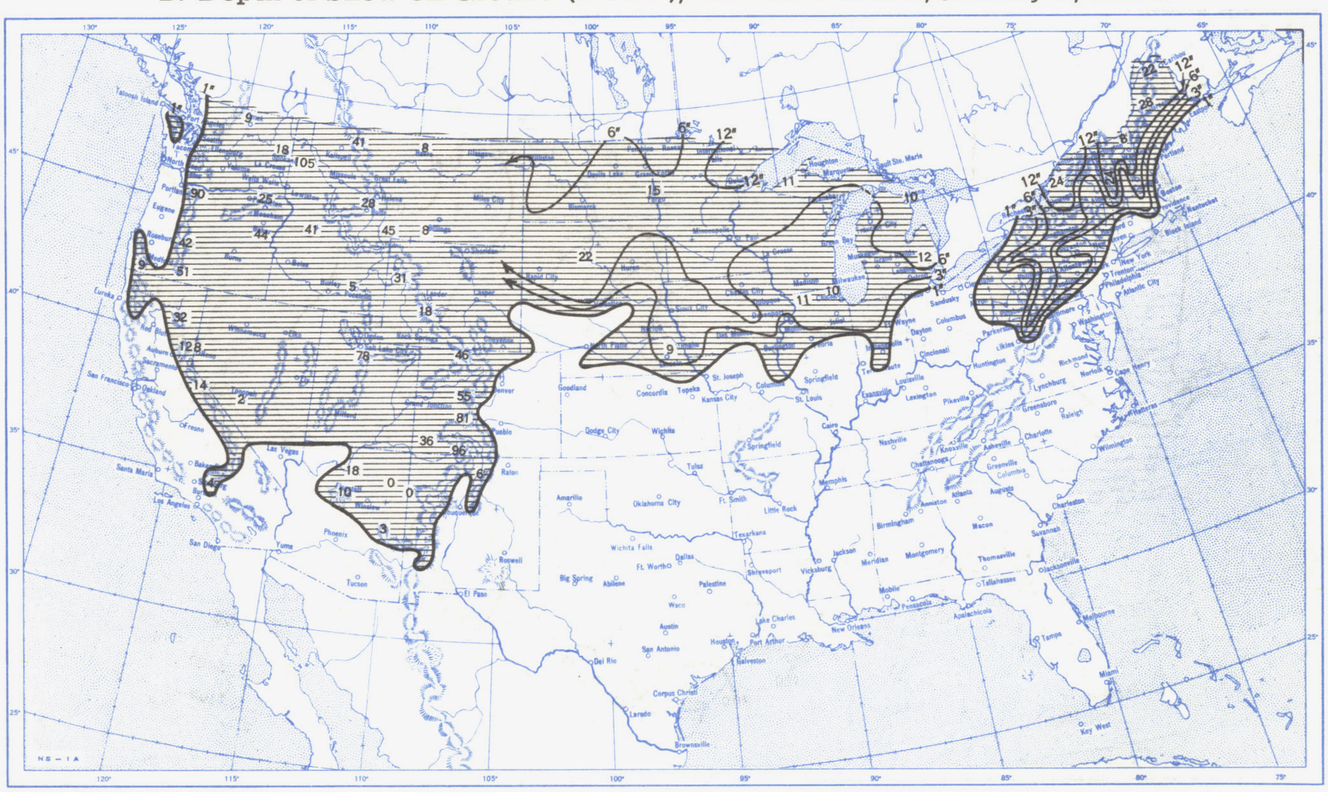


This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

Chart V. A. Percentage of Normal Snowfall, December 1951.

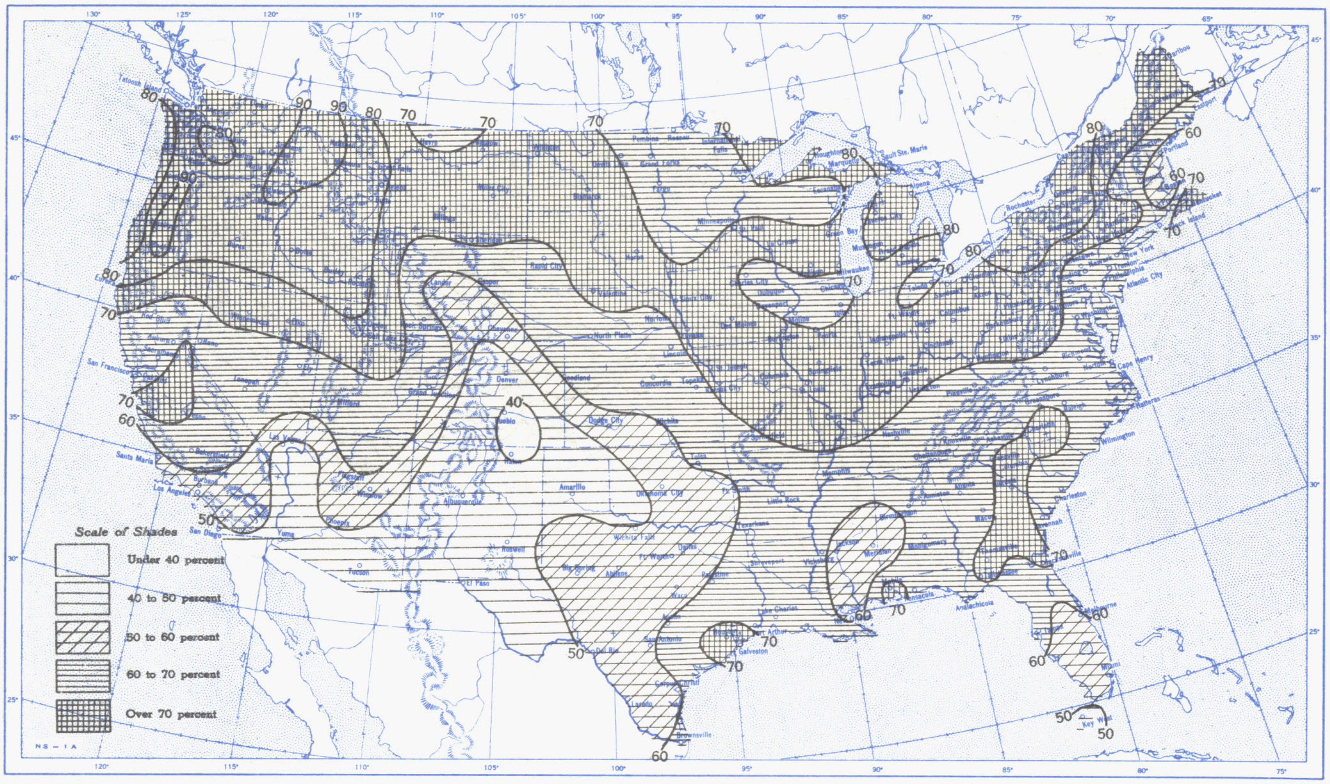


B. Depth of Snow on Ground (Inches), 7:30 a. m. E. S. T., January 1, 1952.

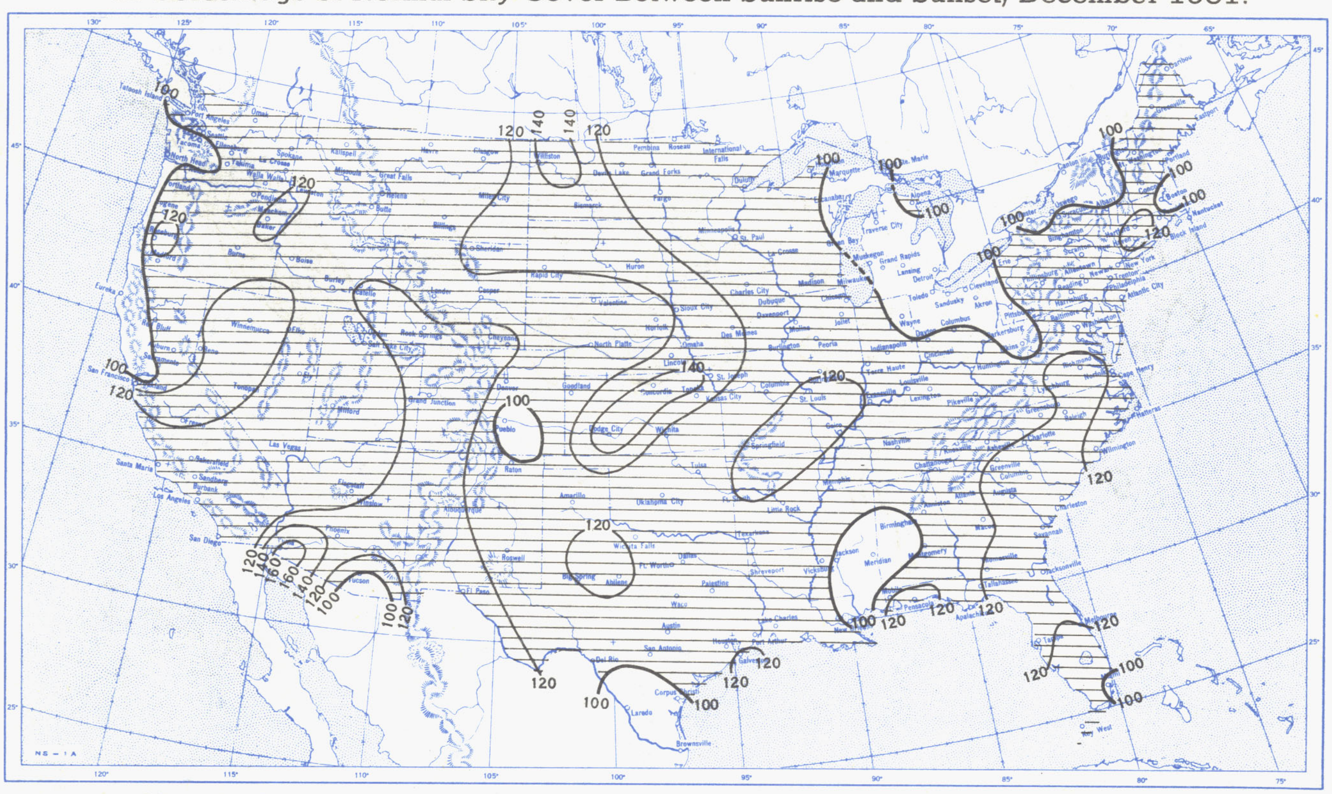


A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record.
B. Shows depth currently on ground at 7:30 a. m. E. S. T., of the Tuesday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, December 1951.

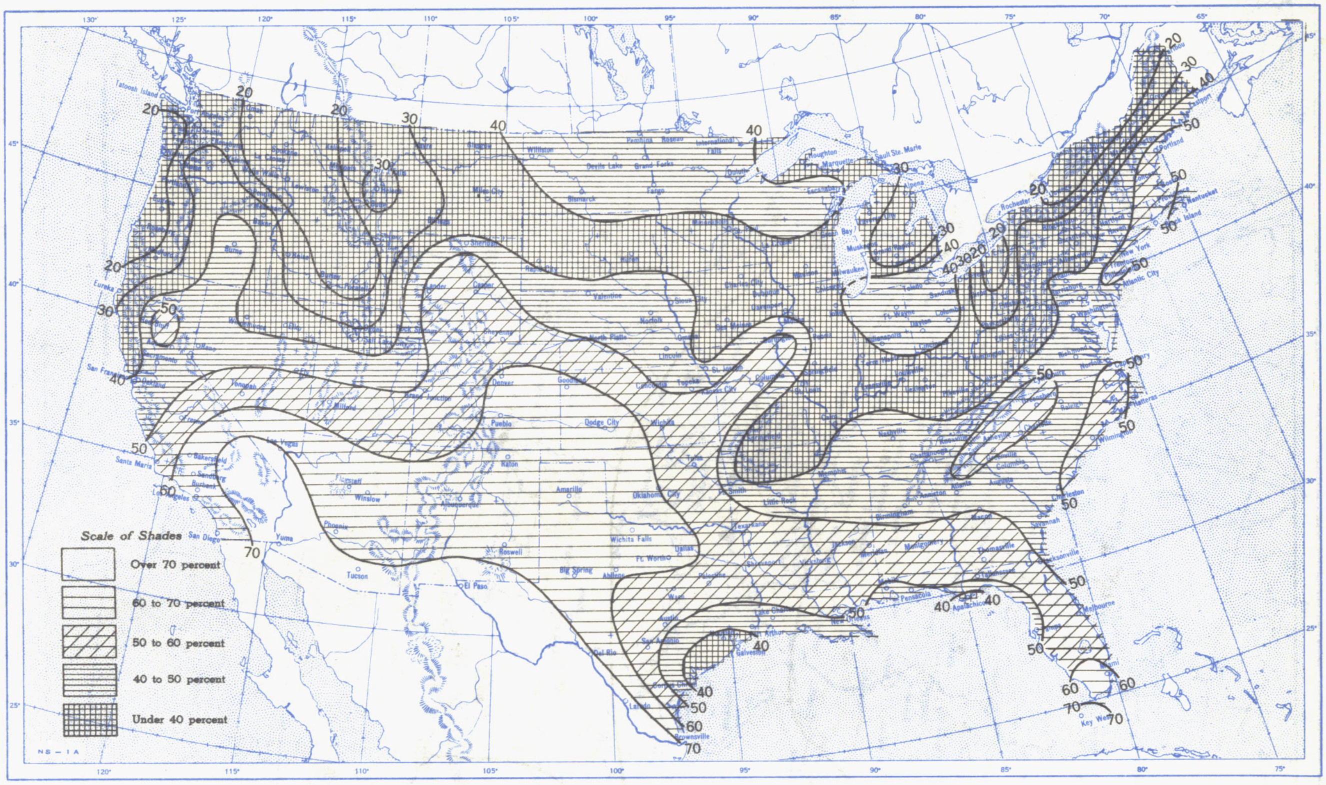


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, December 1951.

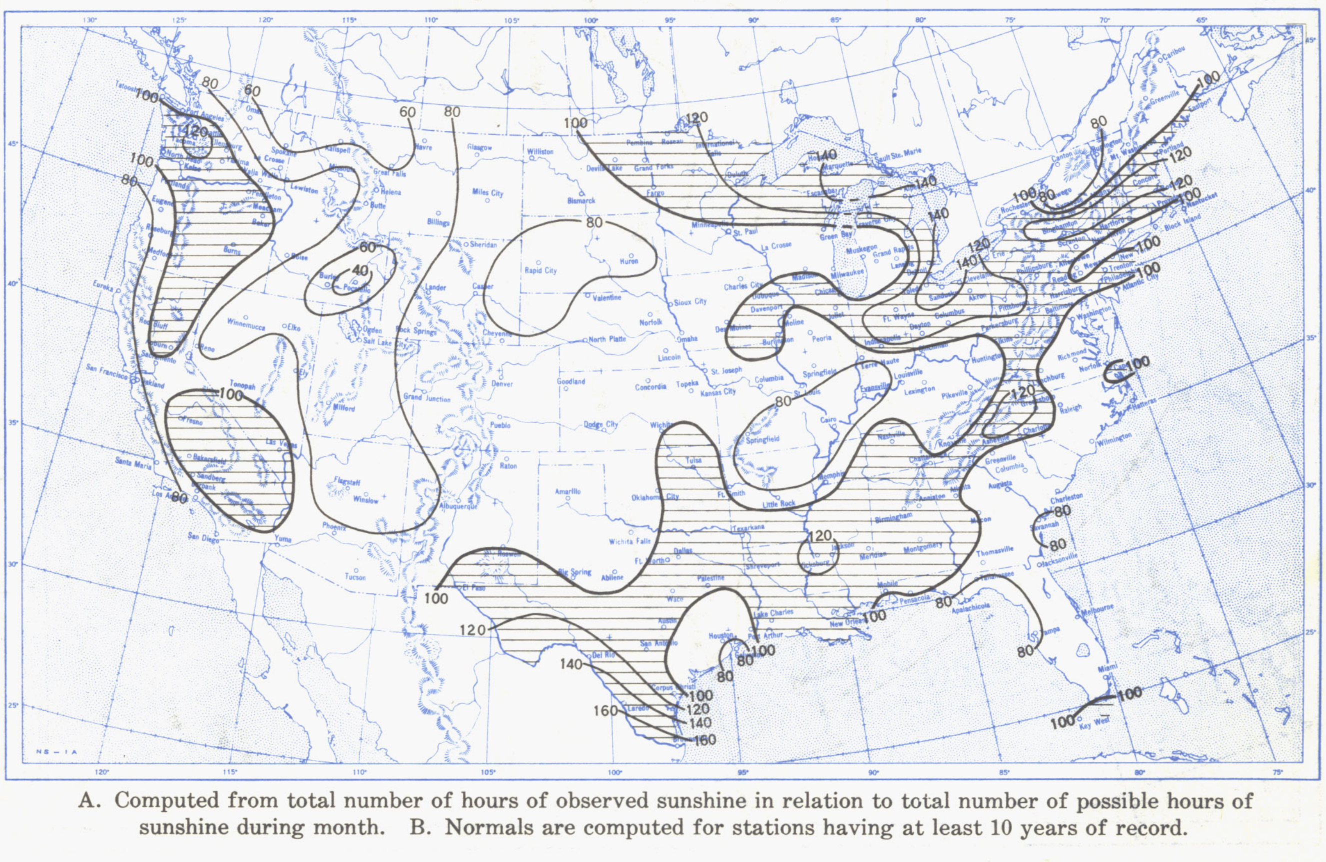


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, December 1951.



B. Percentage of Normal Sunshine, December 1951.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, December 1951. Inset: Percentage of Normal Average Daily Solar Radiation, December 1951.

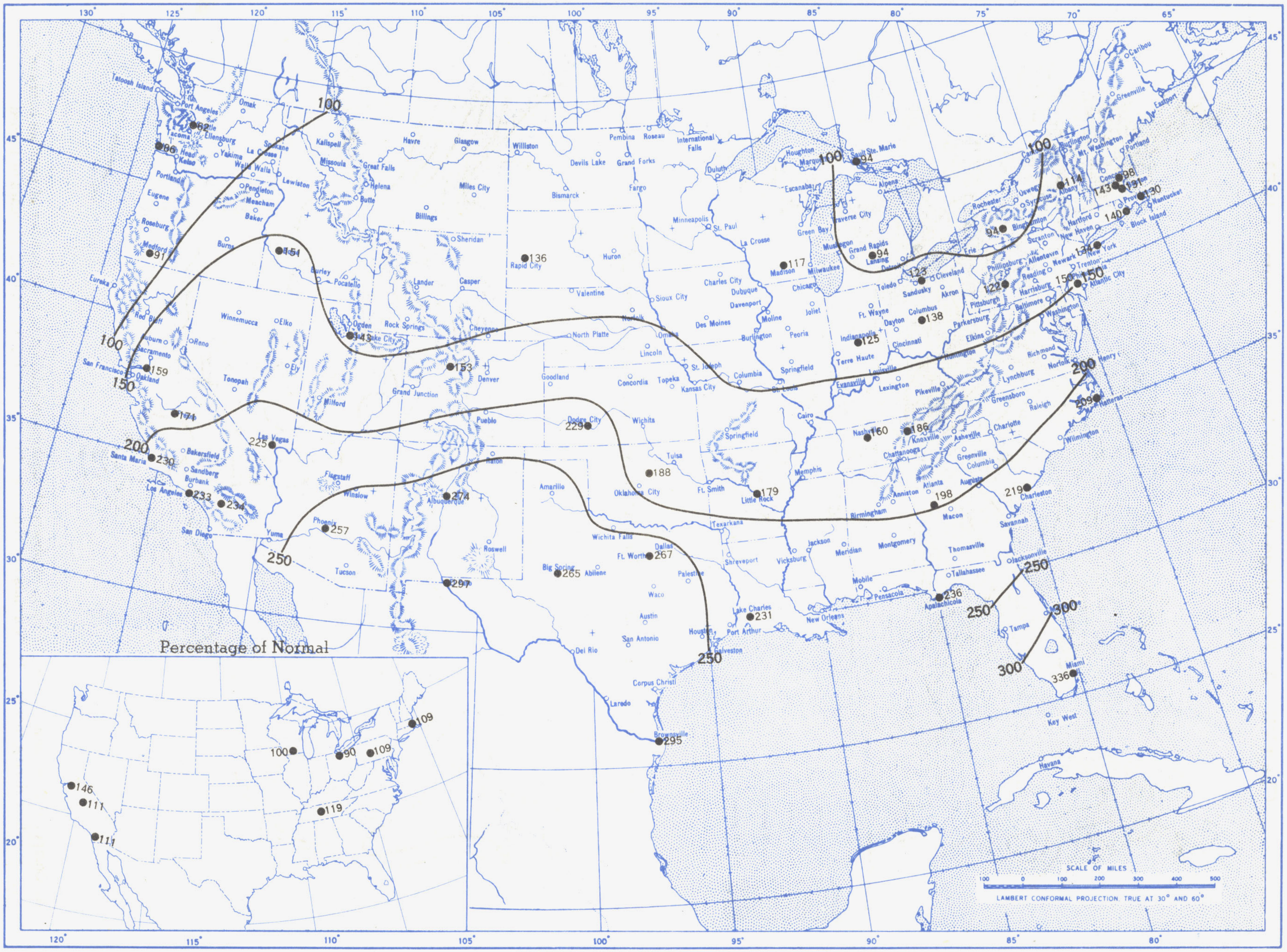
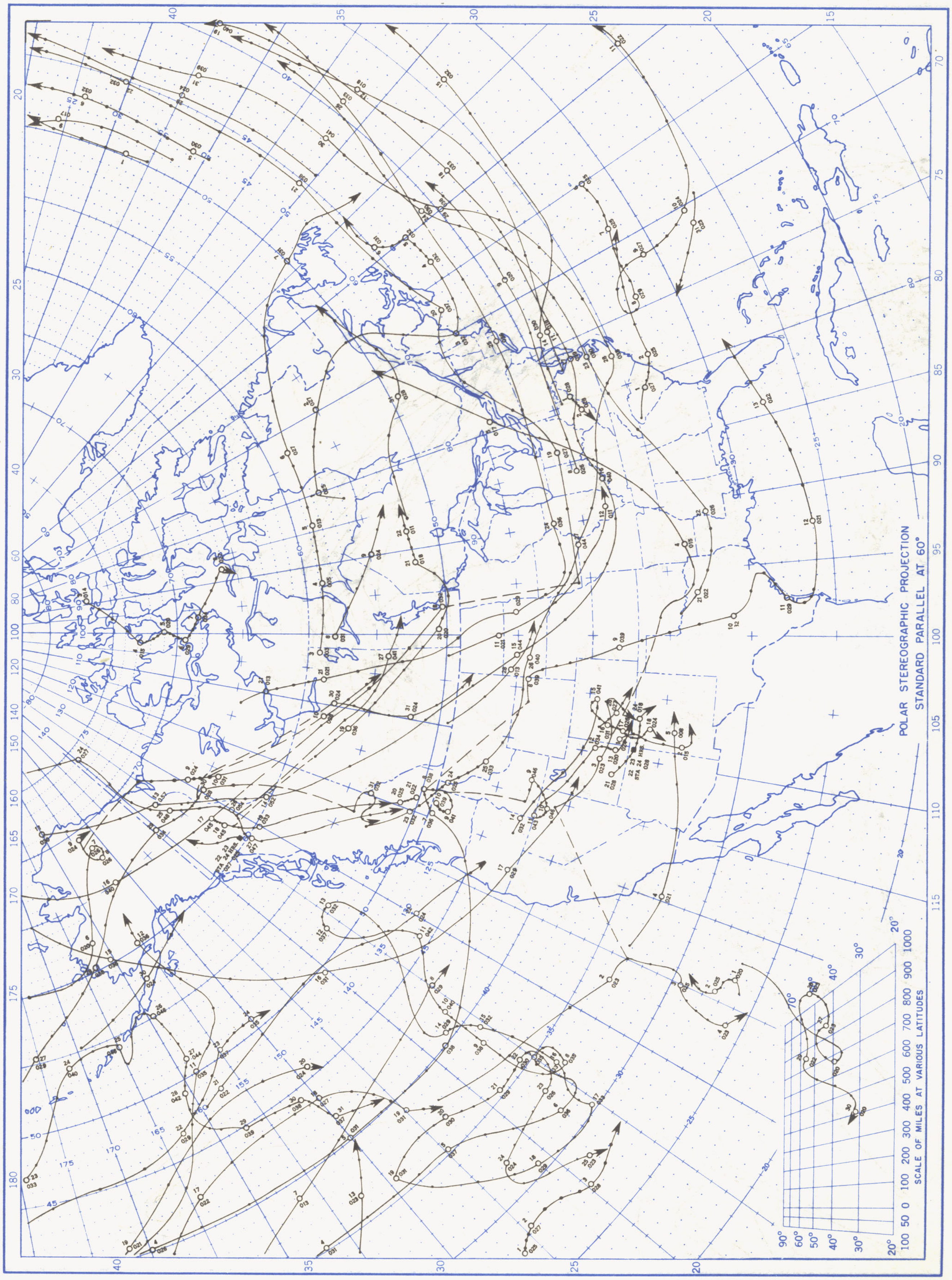


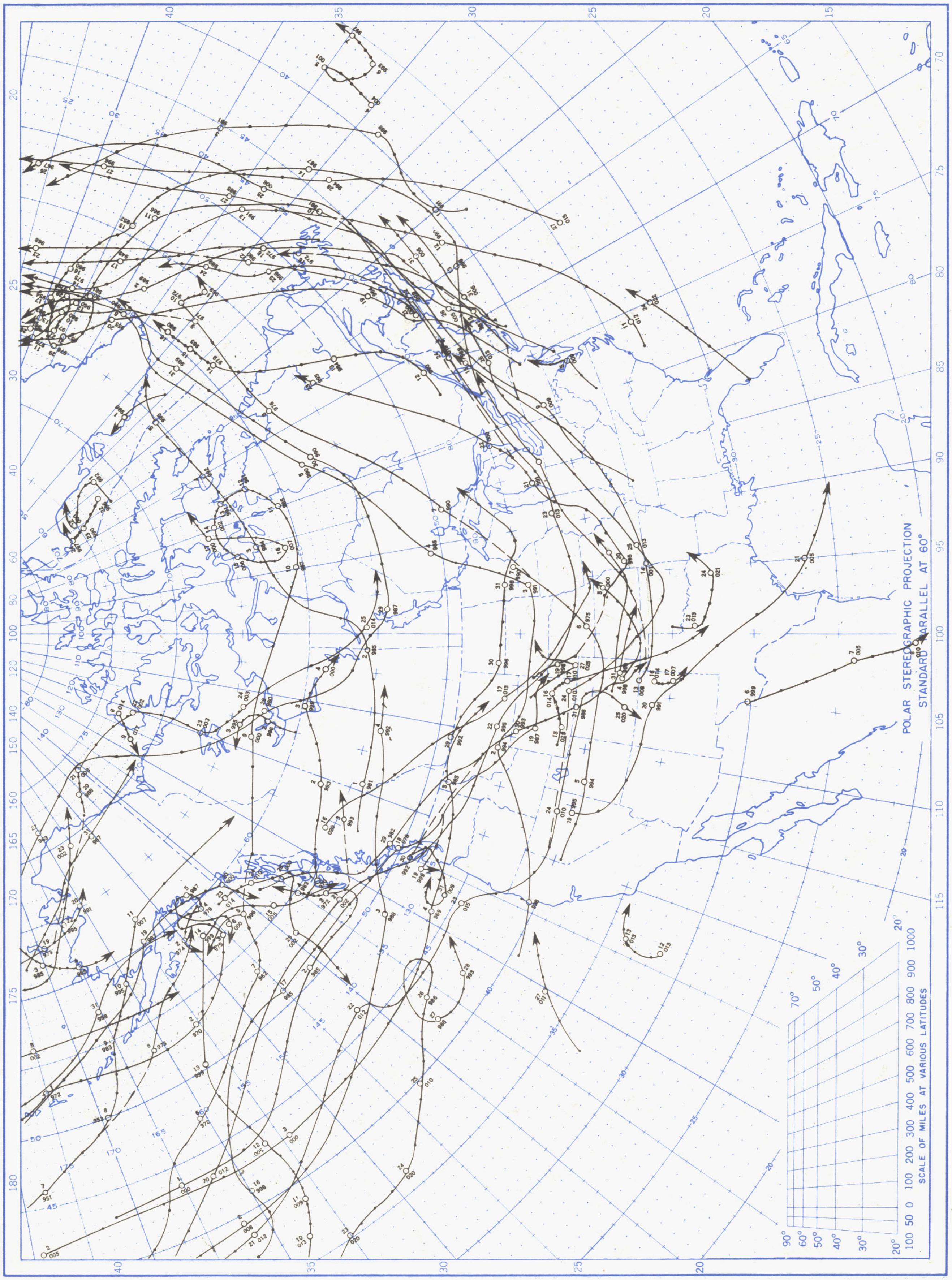
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.$^{-2}$). Basic data for isolines are shown on chart. Further estimates obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, December 1951.



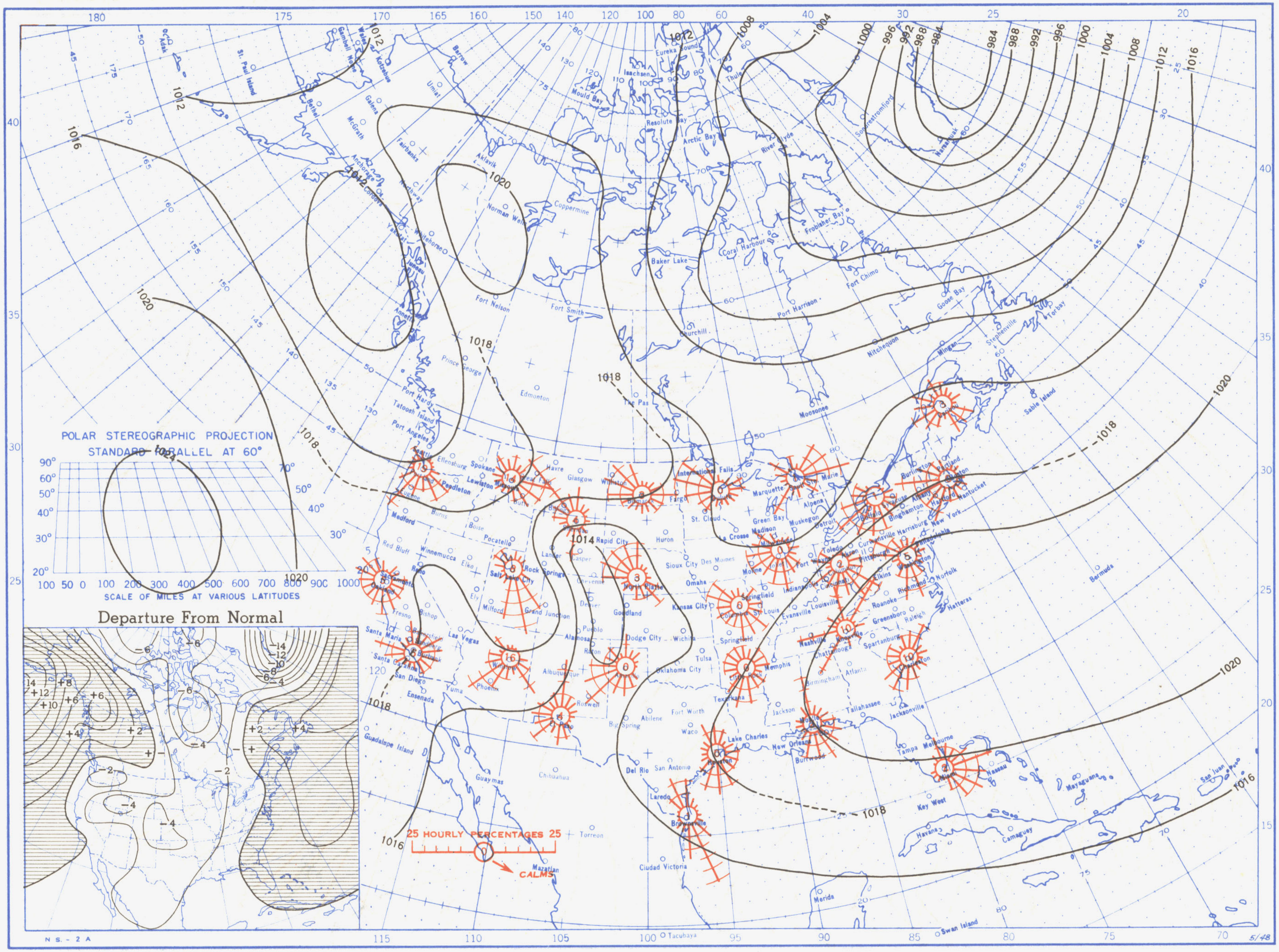
Circle indicates position of center at 7:30 a.m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, December 1951.



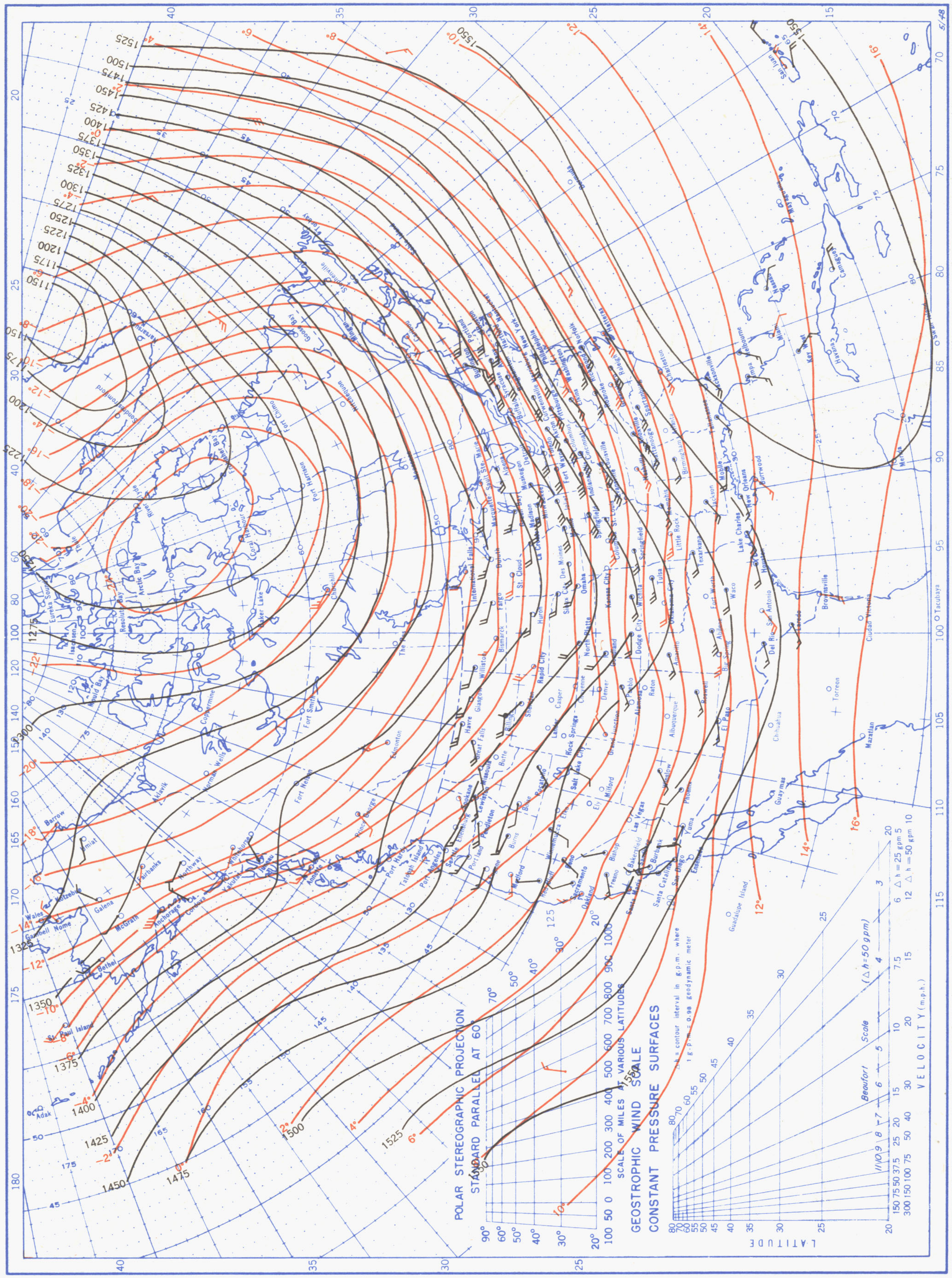
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, December 1951. Inset: Departure of Average Pressure (mb.) from Normal, December 1951.



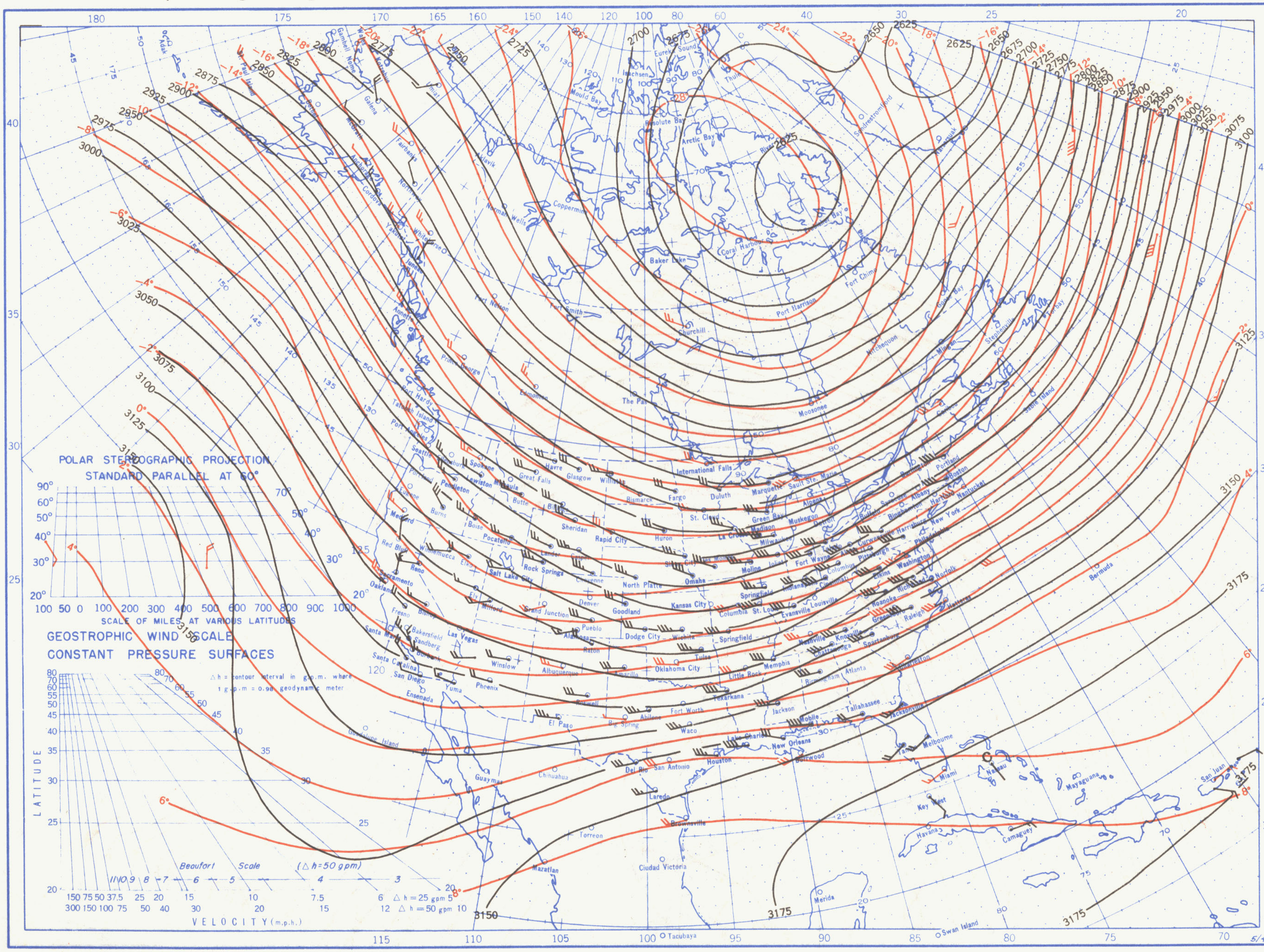
Average sea level pressures are obtained from the averages of the 7:30 a.m. and 7:30 p.m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), December 1951.



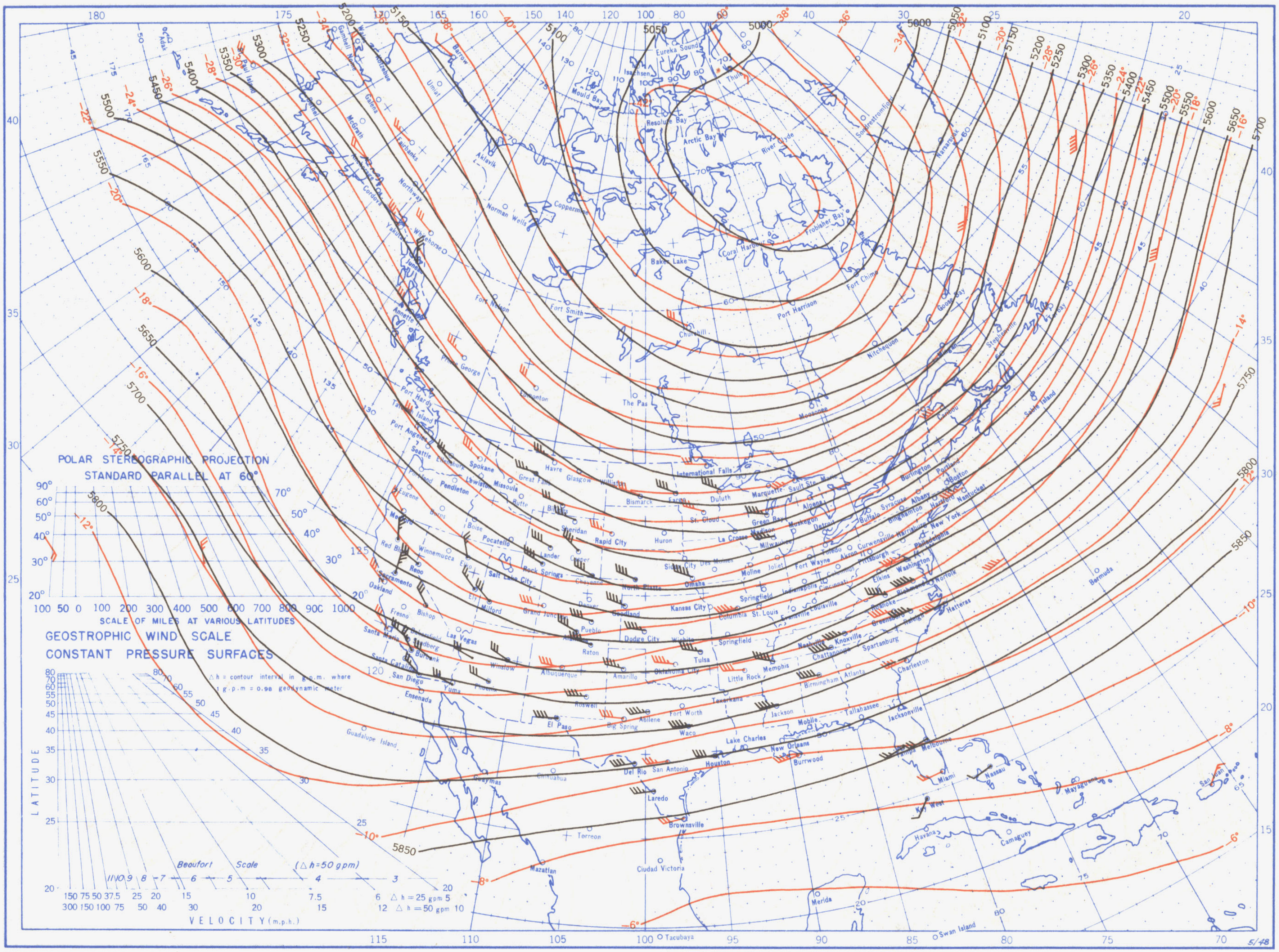
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), December 1951.



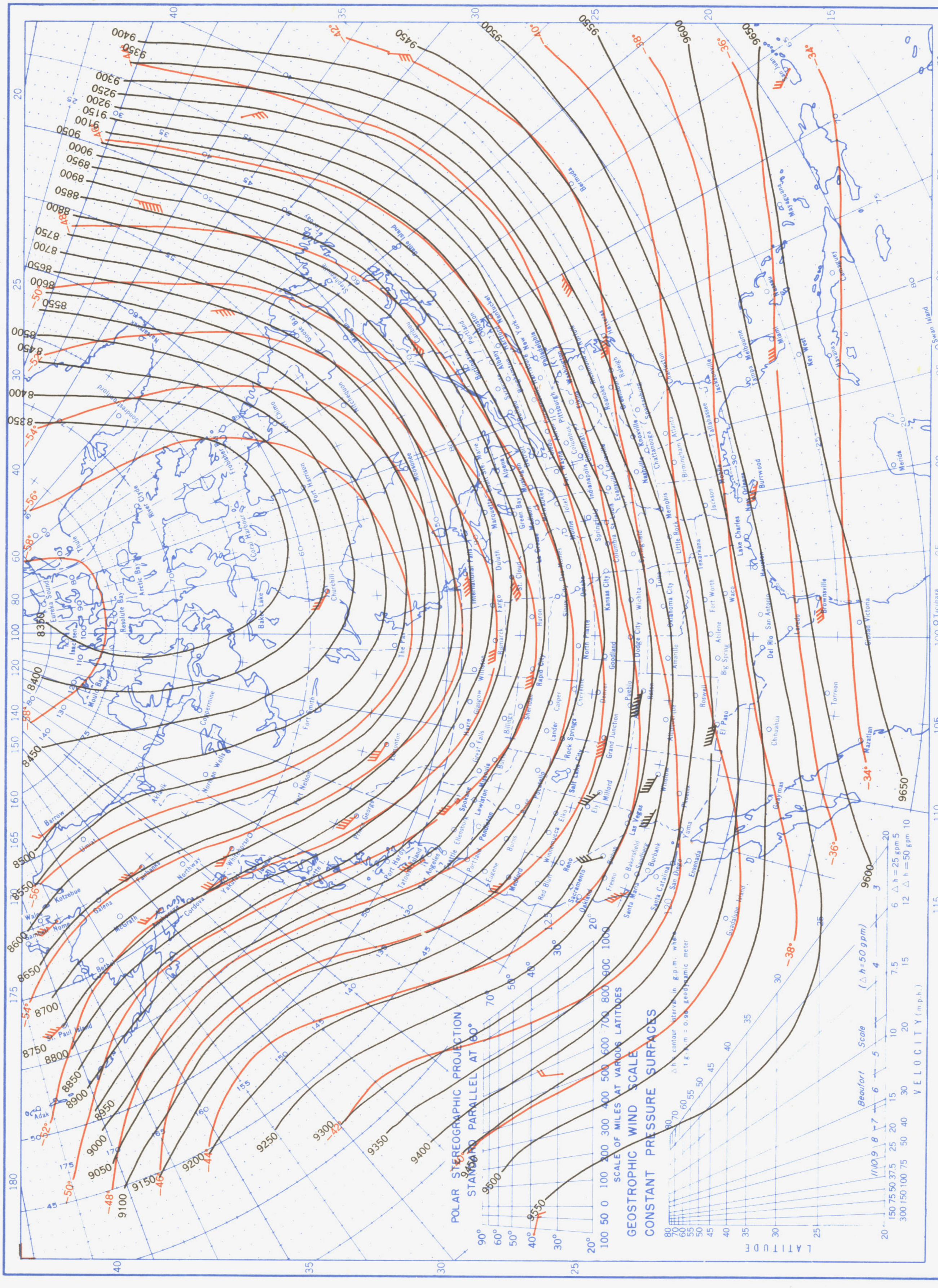
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), December 1951.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.: those shown in red are based on rawins at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), December 1951.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.